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# ACQUISITION AND COMPREHENSION OF A TOOL-USING BEHAVIOR BY YOUNG CHIMPANZEES (*PAN TROGLODYTES*): EFFECTS OF AGE AND MODELING

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**ABSTRACT:** The acquisition of a tool-using ability was investigated in six young chimpanzees (*Pan troglodytes*, 2 to 4 years old). Age-matched pairs were presented with a horizontal transparent tube with a food item inserted in the center, and a wooden tool. Insertion of the tool into the tube was required in order to obtain the food item. One of each pair was exposed to a model performing the task successfully, whereas the age-matched peer was not. Following acquisition, subjects were tested with more complex versions of the task to evaluate their comprehension. Age affected acquisition; older individuals learned to solve the task in fewer number of trials than younger chimpanzees. The presence of a model influenced acquisition only in the 3-and-4 year-old groups and not in the 2-year-old group. Moreover, older individuals made fewer errors when faced with tools requiring modification, and the performance of older individuals on these complex tasks improved with limited practice. These results are related to recent findings on cognitive development in chimpanzees indicating that self-recognition emerges between 24 and 30 months and that 4 year-old chimpanzees can imitate novel arbitrary actions. Comparisons with human cognitive developmental data and findings on the same task with older apes point to the link between the emergence of imitation, self recognition, and comprehension of the cause-effect relation present in this task. Competence in all these domains is somewhat delayed in chimpanzees compared to humans.

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Field observers have often suggested that young chimpanzees acquire specific feeding skills, including those involving the use of tools, through social learning, perhaps including imitative copying (e.g., Boesch, 1991; Goodall, 1986). Imitation (sensu Visalberghi & Frigaszy, 1990), or imitative copying (sensu Galef, 1988; Russon, in press; and Parker, in press) is the relatively faithful reproduction of a novel behavior as a result of observation of another performing the behavior. In a tool-using context, imitative copying should lead the observer to learn the manner in which to use a tool more efficiently than it could learn to do so on its own. However, how social influences affect the acquisition of new behaviors by novice individuals is a matter of conjecture or debate (e.g., Bard, 1992; Tomasello, 1990). Our own studies cast doubt on the notion that monkeys acquire novel behaviors from observing others (Frigaszy & Visalberghi, 1989; Visalberghi & Frigaszy, 1990) but suggest that after providing chimpanzees with appropriate tutorials, chimpanzees do acquire novel behaviors from observing others (e.g., Custance, Whiten, & Bard, 1994; 1995; Custance & Bard, 1994). By tutorial, these authors mean providing a variety of learning aids, such as scaffolding and demonstration, excluding shaping. Without a background knowledge that others are worth watching, there may be only minimal benefit to young chimpanzees (*Pan troglodytes*) accrued from observation of an experienced model (Custance & Bard, 1994; Whiten, Custance, Gomez, Texidor & Bard, in press; Tomasello, Davis-Dasilva, Camak, & Bard, 1987).

Imitative capacities have been documented in studies with chimpanzees who have been shown arbitrary gestural actions by human models (Custance et al., 1994; 1995). These studies suggest that there may be two constraints in imitative learning: a developmental change in the ability of chimpanzees to benefit from the demonstration of a new skill; and the importance of a social relationship between model and imitator (e.g., Russon & Galdikas, 1994). The first constraint is also evident in the imitative performance of human infants. Studies with human children have indicated that observing a model affords a benefit to a child learning a new skill only if the task is nearly within the child's ability at the time the modeling occurs (e.g., Wood, Bruner, & Ross, 1976). If chimpanzees do face this constraint, social influences on learning new skills would be limited among chimpanzees during the very early years of life.

Alternatively and not exclusively, young chimpanzees may be able to copy gestural or arbitrary actions, but still be unable to benefit

from watching a model perform a novel action involving the production of relations between two objects in an instrumental task. Visalberghi, for example, has argued that one of the reasons that capuchins are unable to copy the behavior of a model using a tool is that they do not understand the relation between the movement or properties of the tool and the solution of the task (e.g., Visalberghi, 1993). This limitation is particularly noticeable because some individual monkeys can solve tool tasks quickly after experience with them. In addition, after practice capuchins can solve even difficult tasks quickly but they continue to exhibit errors. These continuing errors indicate that capuchins do not plan ahead of action and/or do not have a mental image of what size and shape tool produces the relations which solve the task. Thus, the conclusion is made that capuchins do not reach the sixth Piagetian stage of "invention of new means through mental combination" (Natale & Antinucci, 1989; Schino, Spinozzi, & Berlinguer, 1990; Visalberghi & Trinca, 1989). Human infants in their first year are capable of solving instrumental problems primarily through associative processes linking action with outcome (e.g., Bates, Carlson-Luden, & Bretherton, 1980); the ability to solve instrumental problems (Connolly & Dalgleish, 1989) or to plan behavior through conceptual processes (e.g., relational concepts, or representation of absent stimuli or events) is increasingly apparent in the second year of life and beyond (e.g., Piaget, 1952; 1954). Chimpanzees use both associative and conceptual processes in solving various problems in captivity (Chevalier-Skolnikoff, 1977; Köhler, 1927; Mathieu & Bergeron, 1981), and certainly the diversity and flexibility of their tool-using behavior in natural settings suggest the presence of conceptual solutions (e.g., Boesch & Boesch, 1990; van-Lawick Goodall, 1968; Sakura & Matsuzawa, 1991; Sugiyama & Koman, 1979). However, it remains unclear whether they can benefit from watching a model solve a tool task.

In this study, we address the relation between learning context (with or without a model) and age in the initial performance of a tool-using behavior in young chimpanzees. We ask three questions: 1) Does age contribute to ease of acquisition of this behavior? 2) Can young chimpanzees benefit from observation of a competent and successful model in the acquisition of this behavior? If so, is an age effect evident in the ability to benefit? and 3) is ease of acquisition associated with comprehension of the important aspects of the task as indexed by performance on the complex tool task?

## METHOD

### *Design*

A two-part experiment was performed. The first phase, *acquisition*, addressed the influence of a social model on the learning of a tool-using skill. In the first part, six subjects were presented with a task which could be solved by inserting a tool into a clear tube to push out a food treat. The subjects were randomly assigned in age-matched pairs to one of two conditions, differentiated by the degree of social scaffolding provided by the experimenter. One member of each pair was presented the task with no aid by the experimenter beyond expression of interest in the food item (No-model group). The other member was shown, by the experimenter, how to solve the task (Model group). Following criterion performance on the task (3 consecutive successful trials over two sessions), subjects advanced to the second part of the experiment.

The second part of the experiment, *comprehension*, addressed the subjects' understanding of the tool task. The aim of this phase was to probe the subjects' understanding of the properties of the tool and the task (see Visalberghi & Trinca, 1989). All subjects were treated equally in this phase: no modeling was provided. In this part, three variations of the tool were provided which required the subject to combine or modify the tool to achieve solution of the task. Each subject completed two blocks of twenty trials (a grand total of 40 trials). Within each block there were five trials for each of the three tool variations and for the original tool.

### *Subjects*

Six chimpanzees (*Pan troglodytes*) in three age-matched pairs were tested. Pair 1, Donald and Jarred, were 2 years of age at the start of testing. Pair 2, Katrina and Scott, were three years. Pair 3, Tank and Keith, were 3.6 years and 4 years, respectively. The first member of each pair (Donald, Katrina, and Tank) was assigned to the No-model group, and the other to the Model group.

These subjects were raised in the nursery at the Yerkes Regional Primate Research Center due to inadequate maternal care at birth or injury (see Bard, 1995; 1994-a for more information with regard to maternal competence in chimpanzees). They were all reared in peer groups of five or six individuals from as early as 3 months of age. All subjects had spent considerable time (minimum of one Atlanta

spring/summer/fall season) in outdoor play yards where trees, branches and leaves fall, exposing each to potential tools. All subjects received exposure to the wooden dowels used for this experiment, however, only during the course of testing. Additional details about the subjects' rearing conditions and the details of normative performance on standardized tests of neonatal neurobehavioral integrity and cognitive/ manipulative skills can be found elsewhere (Bard, 1993; Bard & Gardner, in press; Bard, Platzman, Lester, & Suomi, 1992; Bard, Gardner, & Platzman 1991).

### *Apparatus*

A tube of transparent Lexan (3.8 cm diameter) was mounted horizontally on a metal frame and attached to the interior wire mesh wall of a group play room. A tube 33cm long was used for all except the first 50 trials (during acquisition) of the first two subjects (Donald and Jarred). These initial trials used a tube 48cm long which proved too long for 2-year-old chimpanzees. The tube was positioned approximately 36 cm above the ground, and 5 cm in front of the mesh fencing. It was thus at about shoulder height for our subjects if they were seated in front of it. Food items were fresh grapes or (rarely) small candy-coated chocolates.

Wooden dowels (2.5 cm diameter) were provided as tools. The length of the dowels matched the length of the tube (48 and 33 cm). A single straight dowel was provided as the tool during acquisition. The complex conditions involved the following tools: a) *bundle*: a variety of dowels of different lengths and diameters held together with masking tape. The diameter of the bundle was approximately twice the diameter of the single straight dowel and exceeded the diameter of the opening to the tube; b) *H-tool*: a dowel which was the correct length and diameter but which was blocked at each end with a small perpendicular tool (pencils with masking tape, approximately 12 cm in length), and c) *Short-tool*: two half-length dowels.

### *Procedure*

The procedures were standardized on two pilot subjects, whose data are not included in the following results. Each subject was tested in the setting most conducive to optimal performance for that subject (i.e., some subjects had a peer present for comfort). A favorite adult human provided each subject with a comfortable situation in which to work. These human companions were very familiar and had

maintained a social relationship with the subjects over the course of between 6 months and 3 1/2 years.

### *Phase I: Acquisition*

*No model Group:* The apparatus was baited with a single grape before the subject arrived at the testing site. A tool was placed on the floor below the tube, perpendicular to the longitudinal axis of the tube. Each 4-minute trial began when the subject's attention was directed to the grape by the experimenter giving food barks (vocalizations denoting the presence of preferred foods: Goodall, 1986), looking at the food, and pointing to the food. If no solution occurred within the first 25 trials, the experimenter began a graduated series of interventions to facilitate performance. The first intervention consisted of providing a shorter tube and tool (this intervention was used only with Donald and Jarred). The second intervention involved placing additional food items into the tube at the beginning of each trial while the subject watched. The third intervention involved placing the tool partially into the tube, with several centimeters remaining between the tool and the food. The final intervention was providing a modeled solution prior to each trial. The schedule at which these interventions occurred, and the number of trials per test day, varied across subjects in accord with the experimenter's judgment about the subject's progress and interest in the task.

*Model Group:* In a 30-sec period at the beginning of each 4-min trial, while the subject was attending, the experimenter inserted the tool into the tube, purposefully hitting the interior of the tube with the tool as it entered, and slowly pushed the food item out the far end of the tube. Food barks were given by the experimenter while solving the task. The food item was then shared between the experimenter and the subject. The tube was re-baited in view of the subject, and the tool was placed beneath the tube, as in the no-model group.

For both groups, a trial ended when solution occurred or after 4 min; whichever occurred first. The acquisition phase ended when solution was achieved in three consecutive trials over two sessions. Testing in this phase was completed in 2 months or less for all subjects.

### *Phase II: Comprehension*

All subjects who succeeded in solving the task to criterion in Phase I advanced to Phase II (complex tool conditions) on their next test session. Phase II was divided into two blocks of 20 trials. In each block, four different tools (the original, and the three variations

described above) were provided for five trials each. Within each block, the first trial used the plain dowel, and in subsequent trials in the same block the order of presenting the four tools was determined by the experimenter in accord with the subject's progress and interest. No interventions occurred on these trials. Trials lasted 4 min, or until solution occurred, whichever came first. Testing in this phase began within 5 days of reaching criterion on the acquisition task, and was completed in 2 weeks or less.

### *Analysis*

*Phase I:* Each 4-min trial was divided into 24 10-sec sampling periods. The 10-second sampling periods were scored for four mutually exclusive and exhaustive classes of behavior: 1) no attempts to solve, which included no attention to tool or tube, and exploratory behaviors toward either the tool or the tube; 2) attempts to solve without the use of the tool, which included attempts to solve by reaching directly for the food, and attempts to solve with non-tool objects; 3) attempts to solve with the use of the tool in which the tool was aimed at the side of the tube, at the food, or at the end of the tube, but was not inserted; and 4) correct attempts to solve and success.

*Phase II:* Each 4-minute trial was divided into 48 5-second sampling periods. The size of the sampling period corresponded to the smallest time period that one error could occur, in other words, 5 seconds. Each sampling period was scored for a) success, b) correct attempts, and c) type of errors. Errors were scored with a coding system developed by Visalberghi and Trinca (1989) for use with another species (capuchins) but with the same task and tools. In brief, the errors were defined conceptually as Type I, use of objects that are not combined properly, such as ineffective insertion of a short tool in Short condition; Type II, using objects that are insufficiently modified, such as use of the bundle that was too large, or insertion of the H-tool without removal of the blocking piece on the inserted end; and Type III, using objects of grossly insufficient length, shape, or rigidity, such as insertion of short pieces from the H-tool, or insertion of grass or leaves. An additional error type, Type Z, was noted if a correct tool was chosen but then discarded prior to solution. The frequency of errors by Type (and percent of samples in which errors occurred) was calculated per 10-trial block.

*Reliability:* Many sessions were coded live and all trials in both phases were videotaped for later coding and reliability assessment.

One coder scored all trials of phase I (acquisition) either live or from videotape. Reliability assessments were conducted by an additional coder on 27 trials (percent agreement was 88 and Cohen's Kappa was .80). A second coder scored all trials of phase II (comprehension). Reliability assessments were conducted by a third coder on all 40 trials of one subject. Reliability of comprehension coding consisted of three parts: (1) type of error (percent agreement was 86; Cohen's Kappa was .74); (2) success analysis (percent agreement was 75; Cohen's Kappa was .63); and (3) modification analysis (percent agreement was 94, Cohen's Kappa was .83). These reliability estimates are considered good to excellent (Bakeman & Gottman, 1986).

## RESULTS

### *Phase I: Acquisition*

Five of the six subjects learned to solve the tool task, i.e., they achieved criterion for acquisition in Phase I (see Table 1). The sixth, Jarred, in the model condition, had not learned to solve the task after 163 trials, and testing with this subject was discontinued. A clear effect of age is evident in trials to criterion. The youngest subject required 163 trials; the oldest two subjects required 25 trials and 1 trial respectively.

All subjects were interested in the task. Most subjects initially attempted to solve the task without the tool, i.e., they touched the side of the tube near the food with their hands, trying to reach the food directly. Following failures at direct reaching, subjects attempted to reach the food by inserting their fingers or tongues into the end of the tube, another type of behavior coded as an attempt to solve without the tool. Solution occurred soon after the subject attempted to touch the food with the tool, except for the youngest subject Donald (see Table 2). This subject attempted to touch the food with the tool as early as the 5th trial, and repeatedly thereafter, but did not succeed until much later, after intervention. He was also one of the first subjects tested, and was initially presented with the longer tube. Some of his difficulty with the task appeared to derive from the biomechanical problems posed by a long tool. When the shorter tube and tool were substituted after Trial 77, he rarely attempted to contact the tube with the tool until an intervention was initiated at trial 131. This intervention consisted of having the tool inserted half way into

**Table 1. Performance during Phase I for each chimpanzee.**  
**Interventions: 1, shorter tool and tube; 2, additional food items; 3, tool partially in the tube; 4, model solution before each trial (intervention 4 is considered an intervention only in the no-model condition).**

| Condition | Subject | Age<br>(Yrs;<br>Mos) | Trials to<br>solution | Intervention type<br>and trial |
|-----------|---------|----------------------|-----------------------|--------------------------------|
| No Model  | Donald  | 2;0                  | 163                   | 1(77), 3(131)                  |
|           | Katrina | 2;10                 | 79                    | 1(19), 3(46), 4(67)            |
|           | Tank    | 3;7                  | 25                    | no intervention                |
| Model     | Jarred  | 2;1                  | dropped<br>after 163  | 1(77), 3(131)                  |
|           | Scott   | 2;11                 | 27                    | 1(27)                          |
|           | Keith   | 4;0                  | <1                    | no intervention                |

**Table 2. Summary of behaviors in first and last 25 trials in Phase I (acquisition). \* solved in first 25 trials; + never did solve.**

| Cond.       | Subject | First 25 Trials      |                          |              | Last 25 Trials       |                          |              |
|-------------|---------|----------------------|--------------------------|--------------|----------------------|--------------------------|--------------|
|             |         | Total #<br>Intervals | Attempts to<br>solve (%) |              | Total #<br>Intervals | Attempts to<br>solve (%) |              |
|             |         |                      | No<br>Tool               | With<br>Tool |                      | No<br>Tool               | With<br>Tool |
| No<br>Model | Donald  | 486                  | 14                       | 11.5         | 509                  | 16                       | 9.8          |
|             | Katrina | 600                  | 26                       | 0            | 549                  | 26                       | 5.1          |
|             | Tank    | 579                  | 20                       | 0.3          | *                    |                          |              |
| Model       | Jarred  |                      |                          |              | +                    |                          |              |
|             | Scott   | 589                  | 25                       | 5            | *                    |                          |              |
|             | Keith   | 2                    | 50                       | 50           | *                    |                          |              |

the tube. He subsequently solved the task 2 trials later, and intermittently for the next 30 trials, passing criterion at trial 163.

All the subjects except Keith explored and manipulated the tool prior to attempting to use it to reach the food, and all except Tank showed behaviors combining the tool with the tube just preceding solution. Following their initial solution, only the youngest subject did not proceed directly through 3 successive solutions.

The presence of a model was associated with a substantially reduced number of trials to solution in the two older age groups. The two-year-old who observed the model, however, was unable to solve the task. The 3-year-old, Scott, with a human model, solved the task in approximately one-third the amount of time that Katrina, with no model, took to learn to solve the task (see Table 1). In fact, Katrina received intervention up through modeling by a competent human; Katrina achieved solution after 12 trials of modeling. Among the 4-year-olds, Tank (without a model) solved the task in 25 trials but Keith, with a model, solved in the first trial. The plan was for a human to model for Keith. However, because Katrina was present as his social companion, and she was already proficient at solving the task, we let her model the first trial. Since Keith solved the task after this first model trial, there was no human model provided for him.

### *Phase II: Comprehension*

All subjects solved most tasks but there was some variability in number of successful trials (see Table 3). Again, there appeared to be a difference among subjects attributable to age. The youngest solver (Donald) succeeded at the H-tool and short tools on a few trials but had no success with the bundle. The older subjects were much more successful. The 3-year-olds, Katrina and Scott, solved most trials of all three complex tools. They had more trouble with the H-tool than the other complex tools (both solved 3 out of 5 trials in the first block and 4 out of 5 in the second). The 4 year-olds, Tank and Keith, exhibited the most disparity. Keith solved all trials of all complex conditions in both blocks. Tank, however, solved only 2 out of 5 trials of the bundle in the first block, and never solved the H-tool problem in either block of trials.

Type I errors, inserting one short-tool on each side of the tube, were observed to occur at least once in each subject in the short-tool trials. Occasionally, the younger subjects removed the initially correctly placed single short-tool (Type z error) but neither of the 4-year-olds exhibited this error with the short-tool. Common errors

**Table 3. Number of trials solved and number of errors made by chimpanzees in each block of 5 trials in Phase II (Comprehension). N; Number of trials solved; E; Errors made in each block. ;\* indicates less than 5 trials per block.**

| Condition | Subjects | Regular Tool |   |              |   | Short tool  |   |              |   |
|-----------|----------|--------------|---|--------------|---|-------------|---|--------------|---|
|           |          | First Block  |   | Second Block |   | First Block |   | Second Block |   |
|           |          | N            | E | N            | E | N           | E | N            | E |
|           |          |              |   |              |   |             |   |              |   |
| No Model  | Donald   | 5            | 0 | 5            | 0 | 3           | 3 | 2            | 2 |
|           | Katrina  | 5            | 0 | 5            | 0 | 4           | 4 | 5            | 5 |
|           | Tank     | 5            | 0 | 5            | 0 | 5           | 3 | 5            | 1 |
| Model     | Scott    | 5            | 0 | 2*           | 0 | 5           | 2 | 5            | 5 |
|           | Keith    | 5            | 0 | 5            | 0 | 5           | 0 | 5            | 1 |

| Condition | Subjects | Bundle      |   |              |   | H - tool    |   |              |   |
|-----------|----------|-------------|---|--------------|---|-------------|---|--------------|---|
|           |          | First Block |   | Second Block |   | First Block |   | Second Block |   |
|           |          | N           | E | N            | E | N           | E | N            | E |
|           |          |             |   |              |   |             |   |              |   |
| No Model  | Donald   | 0           |   | 0            |   | 1           | 3 | 1*           | 3 |
|           | Katrina  | 3           | 1 | 5            | 1 | 3           | 5 | 4            | 0 |
|           | Tank     | 2           | 8 | 5            | 5 | 0           |   | 0            |   |
| Model     | Scott    | 5           | 4 | 2*           | 3 | 3           | 4 | 4            | 8 |
|           | Keith    | 5           | 3 | 5            | 0 | 4*          | 3 | 5            | 6 |

with the bundle included attempting solution prior to detaching a tool of an appropriate diameter (Type II error), and attempting solution by using grass, pieces of masking tape, or water (Type III error). With the H-tool, both Type II errors (trying to solve without first detaching the block) and Type III errors (trying to solve with pieces that were too small, or with inappropriate objects, such as grass or water) were

Table 4. Comparison of first and second block of trials in Phase II (Comprehension). C denotes change from first to second block; - decrease, + increase, = no change.

| Conditions   | Total #<br>Errors | Trials with errors<br>(%) |    |                |   | Trials solved<br>(%) |     |                |   | Trials solved with<br>errors/trials solved |    |                |   |
|--------------|-------------------|---------------------------|----|----------------|---|----------------------|-----|----------------|---|--|----|----------------|---|
|              |                   | Trials<br>1-5             |    | Trials<br>6-10 |   | Trials<br>1-5        |     | Trials<br>6-10 |   | Trials<br>1-5                              |    | Trials<br>6-10 |   |
|              |                   |                           |    |                | C |                      |     |                |   |  |    |                | C |
| By Subject   | Donald            | 27                        | 40 | 33             | - | 27                   | 20  | -              | - | 50   | 33 | -              | - |
|              | Katrina           | 57                        | 47 | 40             | - | 67                   | 100 | +              | + | 40   | 40 | =              | = |
|              | Tank              | 88                        | 80 | 67             | - | 47                   | 67  | +              | + | 71   | 60 | -              | - |
|              | Scott             | 57                        | 67 | 83             | + | 87                   | 92  | +              | + | 38   | 18 | -              | - |
|              | Keith             | 22                        | 40 | 33             | - | 93                   | 100 | +              | + | 43   | 33 | -              | - |
| By Condition | No Model          | 145                       | 63 | 53             | - | 57                   | 83  | +              | + | 53   | 48 | -              | - |
|              | Model             | 79                        | 53 | 55             | + | 90                   | 96  | +              | + | 41   | 27 | -              | - |
| By Age       | 3-year olds       | 114                       | 57 | 59             | + | 77                   | 96  | +              | + | 39   | 31 | -              | - |
|              | 4-year olds       | 110                       | 60 | 50             | - | 70                   | 83  | +              | + | 52   | 44 | -              | - |

exhibited by all the subjects. Katrina, the 3-year-old without a model, did not make any errors in the second block of trials with the H-tool.

The percentage of trials with errors is shown in Table 4. Note that Donald, the youngest subject, had relatively few errors, but there were many trials in which he did not attempt solution. He correctly solved only 44 percent of the trials overall, none of the bundle, and only one in each block of the H-tool. In contrast, the older individuals solved the task on 67% to 100% of trials and made attempts to solve with each type of tool.

Exposure to a model during acquisition appeared to affect the subject's performance in the complex conditions (Table 4). More total errors were found in the subjects who did not have a model compared to those who did receive a model (145 compared with 79 errors). Moreover, the percent of correctly solved trials was higher for the model subjects (96% vs 76%). In contrast to acquisition, in the complex conditions, it did not appear that age contributed to either fewer errors (114 vs 110 errors) or a higher percentage of correctly solved trials (88% versus 84% correct).

Performance improved for almost all subjects in the second block of trials compared to the first block (Table 4). This was true if performance was considered as an increased percentage of trials solved (4 out of 5 subjects solved a greater percentage of Block 2 compared with Block 1 trials), a decreased percentage of trials with errors (4 out of 5 subjects), or a decrease in the percentage of solved trials with errors (4 out of 5). Again, by this analysis, the subjects who had models performed better than the subjects who did not have a model. The older subjects did not, however, perform better than the younger subjects in the complex tool conditions.

## DISCUSSION

The answer to the first question we posed was a clear "yes". Age contributed to acquisition and competence in the tool-using task presented to young chimpanzees. The 2-year-old chimpanzees had the most difficulty learning to solve the tool task, whereas the 4-year-old chimpanzees had the least difficulty learning. The answer to the second question was a qualified yes. Observation of a competent and successful model facilitated acquisition, but only for the older subjects. Finally, the answer to the last question was also yes; the ease of acquisition was associated with comprehension. We discuss these findings below in terms of the linkages among spontaneous

acquisition, effectiveness of a model, and other indicators of cognitive abilities.

### *Link between acquisition and effectiveness of a model*

Three- and four-year-olds learned to use the tool more quickly than two-year-olds, and also showed benefit from exposure to a model. It appears that the model was only effective, however, when operating in the "zone of proximal development" (Vygotsky, 1978), as illustrated with the failure to learn by the 2-year-old Jarred. This is similar to the picture with human children; 13 months is the lower limit of age to solve this task spontaneously (Troise, 1991). Children between 13 and 14 months exposed to a model were no more likely to solve this task than like-aged children not exposed to a model (Visalberghi & Limongelli, in press). Thus, the facilitatory effect of a model, for human and some nonhuman primates, can operate only after a certain developmental threshold has been reached. Finally, this study suggests that a 4 year-old chimpanzee may have imitated the solution of the task demonstrated by a conspecific model.

In general, the effect of the model increased in potency with the age of the subject. For chimpanzees two years and younger, and for children 14 months and younger, exposure to a model did not improve the subject's performance with the same objects. Older human and chimpanzee subjects were able to extract more information from the model's behavior such that specific actions might be copied or further direct exploration of the task might be promoted.

### *Link between effectiveness of a model and social cognition*

Recent thinking about the process of social learning in human children suggests that observation of models and participation in the activities of others serves a fundamental role in the development of many features of species- and culture-normal activities (Rogoff, 1990). In humans, this process has at its base the human tendency to attend to other individuals, often called social referencing (Rogoff, 1990; Stern, 1985). Social referencing in humans emerges within the first year of life, and is evident in the normal interchange between infants and others from about 6 months of age onward (Feinman, Roberts, Hsieh, Sawyer & Swanson, 1992), well before infants are able to copy tool-using actions, for example. Other data from Bard's laboratory (Bard, 1991; Bard, in press; Bard, Platzman, Suomi, & Lester, 1994; Bard et al., 1992) have shown that nursery-reared chimpanzees attend

to a human caretaker's face and show social referencing by one year of age (e.g., Russell, Bard, & Adamson, 1995). Gomez (1990) has reported similar capabilities in a hand-reared gorilla interacting with humans.

Tomasello, Kruger, & Ratner (1993) argue that chimpanzee subjects in successful studies of imitation and cultural learning have been reared and tested in predominantly human environments and that studies with individuals living in conspecific groups have not produced evidence of imitation. We agree that the human social environment has a potentially powerful influence in the shaping of chimpanzee behavior (e.g., Bard, 1994-b, Bard et al., 1995) but we would highlight two additional points. The first point deals with the assumption that imitation occurs only in the human environment and, thus, does not occur in the natural habitat (Russon, Bard, & Parker, in press). The existence of neonatal imitation, both in humans (Meltzoff & Moore, 1977; Kuguimutzakis, 1985) and in chimpanzees (Bard, in press), however, suggests that there is a congenital capacity for imitation in both species. Second, the human social environment is potentially as important a shaper of behavior in humans as in nonhuman primates. Therefore, the argument that imitation emerges as a result of being reared within a human environment could hold true for human infants as well as for chimpanzee infants. What remains to be addressed is the question of process: do chimpanzees imitate via processes that are similar to those of humans?

Young chimpanzees might also profit from scaffolding of activities similar to that present in a typical human rearing environment. Available data indicate that adult aid for youngsters' activities is more often serendipitous than intentional in chimpanzees, although a few examples of active "teaching" have been reported (Boesch 1991, see also Bard, 1993; for a review see Caro & Hauser, 1992).

In humans, social attention and attraction to others on the part of the infant is paralleled by activities of others that structure the young individual's learning experiences. The social basis for such learning, and the recognition on the part of the infant that others are capable of more than itself, is evident in the infant's behavior of asking for help. This is a characteristic of young children during tasks which are just beyond their capability, such as 14-month-old human infants given the tube task (Troise, 1991; Visalberghi & Limongelli, in press). It is interesting to note that neither Donald, Katrina, nor Tank, the no-model subjects, made any requests for help from the experimenter. All enjoyed interactions with the experimenters during the task. One

subject from the model condition, Scott, did solicit help from the experimenter. After the model demonstrated solution and the tools were laid under the tube, Scott picked up the tool, handed it to the demonstrator and looked expectantly at the tube. Whether soliciting help is an individual characteristic or a product of age and test condition is unanswerable from our data set. All the children tested by Visalberghi & Troise (1993) asked for help prior to learning to solve the task.

*Link between acquisition, effectiveness of a model, and cognitive abilities*

Our findings can also speak to a proposed link between the ability to recognize oneself in a mirror (MSR) and the ability to imitate a model's actions (Lin, Bard, & Anderson, 1992; Parker, 1991; Whiten & Ham, 1992). The two youngest subjects in the present study, Jarred and Donald, were both tested for ability to recognize themselves in a mirror when they were 2.1 years of age, at the same period of time as the tool task (Lin et al., 1992). The two subjects performed at an equivalent general level (uncertain self-recognition). In the present study, Jarred was not able to solve the task following 163 trials in which a model solved the task while he watched. Donald, in contrast, eventually solved the task without the aid of a model. Additionally, Tank exhibited probable self-recognition at 3 years, 7 months and Keith definitely showed evidence of self-recognition at 2 years, 4 months. Additional evidence suggests MSR develops between 28 and 30 months in chimpanzees (Bard, Roosevelt, & Love, 1995), or as early as 14 months under conditions of extensive mirror experience (Inoue, 1994).

These findings do not support the notion that ability to recognize one's self in the mirror is necessary to succeed at a tool-using task, nor that it is sufficient to predict benefit from observing a model in acquiring a novel tool-using behavior. A more definite test of the lack of a link of MSR with tool use (or imitation of tool use) would be success in the tool task (or benefit from the model in a tool task) combined with the absence of MSR such as is evident in monkeys (Anderson & Marchal, 1994; Anderson & Roeder, 1989). We believe that the ability to benefit from a model may link better with indicators of cognitive capacity other than self-recognition.

The tool task used in this study is designed to differentiate competent performance mediated by associative processes from performances mediated by conceptual processes (Visalberghi &

Trinca, 1989). If subjects can solve all the complex conditions without error then recognition of the causal relations present in the task is indicated. Both human and chimpanzees infants tested to date exhibit incomplete comprehension. Children given the complex tasks displayed errors, just as did the chimpanzees. Sometimes the errors persisted for several months following initial acquisition (Troise, 1991). In fact, only children at 26 months, solved the complex conditions without errors. Apparently the complex conditions do require more from the subject than direct generalization of the behavior which led to success previously. Nevertheless, the decline in inappropriate behaviors and the occasional immediate success with a novel complex condition in both taxa suggest that a conceptual basis for behavior emerges readily in children and apes of appropriate developmental status.

### *Comparison with other species*

A study using the same tool task has been performed with bonobos, chimpanzees, and orangutans (Visalberghi, Frigaszy, & Savage-Rumbaugh, 1995). The subjects ranged in age from three years to over 20. Acquisition by the older apes was almost immediate and quicker than for the young subjects in the present study. Both development and previous experience are likely important contributors to the differences in the rapidity of acquisition. The two youngest subjects, which overlapped in age with the subjects in this study, solved the task about as quickly as the subjects of the current study. The very youngest bonobo subject (3 years of age) did not solve the task in 13 5-minute trials of which the last 5 were interspersed with 10 demonstrations of solution by a conspecific. The other young chimpanzee subject (3 years and 6 months) solved on his 7th 5-minute trial with no exposure to a model, and followed a course of acquisition similar to that observed in the subjects in this study. These results provide corroborating support for our hypothesis that age constrains both acquisition and the effectiveness of a model.

Some capuchins learned to solve the tool task within 2 hours, whereas others have never learned (Visalberghi, 1993). In contrast to humans and apes, modeling solution of the tube task had only nonspecific effects on behavior toward the tool task in both adult and juvenile capuchins (Visalberghi 1993; for an overview of social influences on tool use in monkeys see Frigaszy & Visalberghi, 1990 and Visalberghi & Frigaszy, 1990).

## *Conclusions*

The field setting provides important information on the development of tool use in chimpanzees. In nature, young chimpanzees learn to use tools at tool sites in the presence of their mothers and after watching them for extended periods. During the long tool-using sessions, infant chimpanzees explore, chew, and play with discarded tools, and exploit the food obtained by their mothers (and other individuals). In this social milieu, they gradually acquire their skills in using tools (Boesch, 1991; Boesch & Boesch, 1990; Goodall, 1986; Matsuzawa & Yamakoshi, in press; McGrew, 1992). A field site is surely not the ideal place in which to study experimentally the possible influences of exposure to model on learning. However, it provides insight on the variety of factors which are involved in the acquisition of skills in a social setting. The present experiment used nursery-reared chimpanzees for which the social milieu was peers and humans. In this case exposure to models was controlled. Our results highlight the positive role that watching somebody performing a tool using behavior can have on its acquisition. This study also demonstrates that, as is the case for human children, there is no advantage to chimpanzees of observing a model when the task is too far beyond their capabilities, i.e., the observers are too young. Although all the chimpanzees older than 2 years learned the tool task, they all showed errors in modification of a complex tool prior to its use. Young chimpanzees, like young children, evidently have an incomplete understanding of the properties of a successful tool. Further confirmation of the generality of our findings awaits future research.

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## JUMPING SPIDERS ALTERNATE TURNS IN THE ABSENCE OF VISUAL CUES

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**ABSTRACT:** The abilities of four species of diurnal jumping spiders (*Helpis minitabunda*, *Portia fimbriata*, *Trite auricoma*, and *Trite planiceps*) and one species of nocturnal clubionid spider (*Clubiona cambridgei*) to maintain approximately straight paths by alternating turns in the absence of visual cues was investigated. Under infra-red light (observed using infra-red video), individual spiders were run through a maze comprising a single forced turn and then a choice of turning in the same or opposite direction to the forced turn. At the second (free) turn, each species turned in the direction opposite to the forced turn (i.e., alternated turns) more frequently than it turned in the same direction. There was no evidence that species differed in tendency to alternate turns. In nature, jumping spiders may use this ability to navigate in the absence of visual cues when foraging or escaping predators in darkness. It is suggested that alternation of turns by jumping spiders depends on proprioceptive information gathered during previous turns.

### INTRODUCTION

Turn alternation is the tendency of animals to turn in the direction opposite to the previous turn after a forced turn or at successive choice situations. This tendency has been described in a wide taxonomic range of animals (for review, see Hughes, 1989), and it has been suggested that turn alternation is used by animals in nature as a means of approximating straight paths in the absence of external directional cues (Dingle, 1965; Hughes, 1978). Maintaining straight paths may facilitate exploration, dispersal, foraging, and escape behaviours (Hughes, 1990; Richman et al., 1987).

Jumping spiders (Araneae, Salticidae) are unique amongst spiders, as they have complex eyes and acute vision (Williams & McIntyre,

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1980; Blest & Carter, 1987). Although vision-dependent orientation and navigation abilities of jumping spiders have been studied (Hill, 1979; Tarsitano & Jackson, 1992; Jackson & Wilcox, 1993), other orientation mechanisms also underlie their behaviour. For example, Land (1971) found that, following target detection by lateral eyes, jumping spiders made turns to orient toward targets and that these turns did not depend on visual feedback during the execution of the turn. That is, these turns are governed by an 'open-loop' system, whereby the turning angle is pre-set by the eyes, and the turn is mediated by internal information, rather than information received by the eyes during the turn.

Jumping spiders also retain a memory of their relative position in space, using combinations of route-referent, gravitational and visual cues. They use this information while making detours to re-orient toward targets after moving to new locations (Hill, 1979). Although Hill (1979) demonstrated that visual feedback during locomotion is not necessary for accurate re-orientation, there appears to have been no previous studies of whether jumping spiders can maintain straight paths in the absence of visual cues for pre-setting a target position. The present study investigated whether jumping spiders alternate turns, thereby compensating for deviations from straight paths, in the absence of visual cues either for pre-setting orientation or as feedback during locomotion.

## METHOD

### *Spiders*

Two species of jumping spiders, *Trite auricoma* and *T. planiceps*, and a species of nocturnal clubionid spider, *Clubiona cambridgei*, were collected in the vicinity of Christchurch, New Zealand. Another two species of jumping spider were collected from elsewhere: *Helpis minitabunda* was collected in Auckland, New Zealand, and *Portia fimbriata* was obtained from a laboratory culture originating from near Cairns, Australia. Only adult spiders with all limbs intact were used. They were maintained using the standard procedures described by Jackson and Hallas (1986).

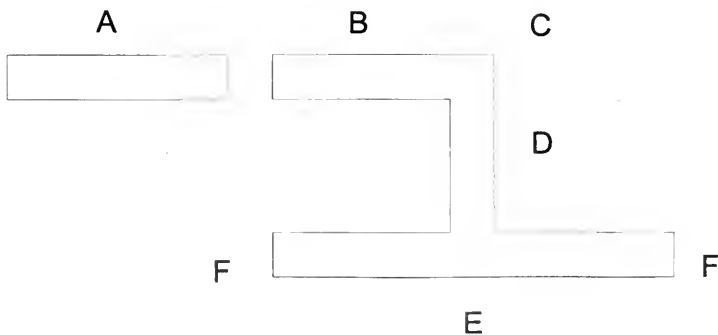
### *Apparatus*

The testing arena was designed to present the subject with a

single forced turn followed by a free turn on a flat perspex runway (Fig. 1). All sections of the runway were 10 mm wide, and all turns were 90°. The 'starting platform', 'entry platform', and 'ramp' were all 50 mm long. The runway on each side following the choice point was 50 mm long.

The testing arena was placed in a tray containing water, and the water level was maintained so that a meniscus formed against the arena edge leaving only the upper surface of the arena out of the water. This was usually adequate to keep the spiders on the arena because all of those tested tend to avoid water.

All experiments were conducted inside a wooden light-proof cabinet (800 mm high, 1200 mm long, 500 mm deep) and were observed using an infra-red (IR) video and light-source that was set up within the cabinet and connected to a monitor positioned outside. There was a heavy black satin sleeve (500 mm long) attached to a 150-mm hole in the wall of the light-proof cabinet. By reaching through this sleeve, the experimenter could operate experiments without allowing light to enter the cabinet. The experimenter's arm remained within the sleeve while experiments were in progress, thereby eliminating the possibility that light could enter the cabinet during withdrawal of the arm. The inside of the light-proof cabinet was painted matt black and the door surrounds contained soft black rubber seals that overlapped the door, thereby excluding light.



**Figure 1.** Testing arena. (A) Starting platform, (B) entry platform, (C) forced turn, (D) ramp, (E) choice point, (F) end.

### *Procedure*

The spiders were maintained and tested under a laboratory photoperiod of 12L : 12D. All tests were carried out during the light phase, although no tests were conducted during the first and last 2 h of the light phase.

To begin a test, a spider was placed on the starting platform outside the light-proof cabinet. This was achieved by holding the platform in front of the spider and gently touching its hind-most legs with a camel hair brush so that it walked forward onto the platform. The spider usually stopped at the far end of the platform long enough for the test to be started. If the spider remained active, it was detained by repeatedly rotating the platform. Once the spider stopped moving, the starting platform was placed into the water (under IR light) by holding it with a hand that extended through the sleeve. The starting platform was then pushed toward the entry platform so that the two platforms joined to form a single 100-mm-long runway.

Spiders then walked off the starting platform and along the entrance platform to the 90° 'forced turn'. Half of the tested individuals of each species were forced right, and the other half were forced left. Following the single forced turn, the spider walked along the ramp until it encountered the 'choice point' where it was given the option of turning either in the same direction as the forced turn (repeating), or in the opposite direction to the forced turn (alternating). A choice was defined as having reached the end of one of the runways following the choice point. Each subject was tested once. However, if a spider failed to complete a test by leaving the arena (e.g., jumping or walking onto the water surface) or did not complete the test within 10 min, it was retested at least 2 h later. Any spiders that failed to complete the test on the second attempt were discarded.

### RESULTS

In the absence of visual cues for pre-setting a target or as feedback during locomotion, each species alternated turns more frequently than it repeated turns. The numbers of each species tested, the number and percent that alternated turns, and the result of one-sample chi-square tests can be seen in Table I. There was no evidence that the five species differed in frequency of turn alternation (test of independence,  $\chi^2 = 7.08$ ,  $df=4$ ,  $p > 0.1$ ).

**Table 1. Frequency of turn-alternation.  $\chi^2$ ; test of goodness of fit,  $H_0$ : equal proportions alternating and repeating turns.**

| Species                    | N  | Number alternating | Percent alternating | $\chi^2$ | $p$    |
|----------------------------|----|--------------------|---------------------|----------|--------|
| <i>Clubiona cambridgei</i> | 28 | 24                 | 86                  | 14.29    | <0.001 |
| <i>Helpis minitabunda</i>  | 36 | 26                 | 72                  | 7.11     | <0.01  |
| <i>Portia fimbriata</i>    | 21 | 17                 | 81                  | 8.05     | <0.005 |
| <i>Trite auricoma</i>      | 79 | 50                 | 63                  | 5.58     | <.025  |
| <i>Trite planiceps</i>     | 60 | 46                 | 77                  | 17.07    | <.001  |

## DISCUSSION

That *C. cambridgei* alternated turns is not surprising, as this species is a nocturnal hunter that may be heavily reliant on non-visual cues for orientation in natural conditions. Besides, turn-alternation has been previously described in another clubionid spider, *Clubiona holosericea* (Schäfer, 1982). However, that the jumping spiders alternated turns in the absence of visual cues may be more surprising. Jumping spiders are generally considered to be strictly diurnal, actively hunting during the day and seeking shelter in crevices or nests for the night (Jackson, 1979, 1988; Richman & Jackson, 1992; Wise, 1993). It is therefore interesting to find that, when visual cues are absent, jumping spiders move about on an arena rather than remaining stationary, and are able to correct for deviations from a straight path by alternating turns.

Perhaps some jumping spiders are not as strictly diurnal as is commonly supposed and may rely on non-visual orientation mechanisms during navigation and prey-capture in darkness. *Trite planiceps* is known to be able to catch flies in darkness (Forster, 1982) and there is anecdotal evidence that some jumping spiders may forage after nightfall (Reiskind, 1982). Also, many jumping spiders may be subject to attacks by nocturnal predators (Jackson, 1976; Jarman & Jackson, 1986), and these attacks may sometimes force jumping spiders to flee their nests in darkness. Once outside their nests, jumping spiders would be advantaged if they could rapidly distance themselves from the predator by approximating a straight-line escape path. Alternating turns at sequential obstructions would be a

useful mechanism for maintaining straight-line escape paths from nocturnal predators.

The present study was designed primarily to investigate only whether jumping spiders alternate turns when visual cues are absent, rather than to identify the sensory mechanisms underlying navigation in these conditions. However, because tactile cues were minimised by conducting experiments on an arena that lacked walls, it seems unlikely that turn alternation was mediated solely by tactile-dependent responses such as 'centrifugal swing and thigmotaxis' (Schneirla, 1929; see Hughes, 1989). Instead, it appears likely that proprioceptive cues were involved. Recent studies have indicated that proprioceptive feedback generated by 'bilaterally-asymmetrical leg movements' (BALM, Hughes, 1985) may be used by arthropods during turn alternation. Jumping spiders appear to rely on proprioceptive cues gathered by stepping movements of legs to mediate orientation toward visual stimuli in light (Land, 1972). That spiders also rely on proprioceptive cues to mediate turn alternation has been suggested previously by Hill (1979) and Schäfer (1982). Further studies investigating cues used by jumping spiders during orientation and navigation in darkness are clearly required.

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## ATTRACTIVENESS OF COMPOSITE FACES: A COMPARATIVE STUDY

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**ABSTRACT:** Data are presented which give cross cultural generality to the observation by Langlois and Roggman (1990) that young southwest American college students found composite faces more attractive than the individual faces from which they were derived. These authors attributed the phenomenon to a cognitive mechanism of prototypicality originating in an evolutionary process of stabilising selection towards facial averageness. In this study New Zealand Caucasian and New Zealand Chinese students, together with indigenous students in China, Nigeria and India chose composite New Zealand Caucasian faces as more attractive than the individual faces from which they were constructed. The preference was greater for female than for male faces. Caution is expressed over attributing the phenomenon to either typicality or stabilising selection.

### INTRODUCTION

Langlois and Roggman (1990) digitised photographs of student faces and arithmetically averaged groups of the resulting matrices of numeric grey values to construct composite portraits. Southwest American undergraduates rated the individual and composite faces for attractiveness. Both male and female composites were rated as more attractive than the individual faces from which they were derived.

The attractiveness of the composite female face was noted long ago (Austin, 1877, Stoddart, 1886) but Katz (1952) was probably the first to make the general claim that average is beautiful. "Apparently, in contrast with intelligence tests, where what is average characterises mediocrity, the average represented in the composite portrait represents the norm of beauty." (p. 211). He concluded that the absence of asymmetries in the composite gave it "ideal traits."

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Concluding, like Katz, that composites derived in this way are average faces, Langlois and Roggman interpreted their results as evidence of an evolutionary process of stabilising selection towards averageness which governs our perception of facial attractiveness and gives it an important role in mate selection. As a proximal mechanism, Langlois and Roggman invoked the cognitive concept of prototypicality.

Basically, stabilizing selection recognizes the population mean for a particular trait as the optimum class. Deviations from it will be selected against. (Johnson, 1976). If average human faces indicate biologically optimum individuals, and if composite faces are average faces, then Langlois and Roggman have provided an intriguing evolutionary explanation of our preference for attractive partners.

While it may be difficult to show that the possessor of an average face is an optimum individual it is nevertheless obvious that something is amiss with one who has two eyes of different size and on the same side of the face.

Is the attractiveness of the composite face a general phenomenon in our species? As Langlois and Roggman admit, evidence from south west American undergraduates is insufficient to justify the conclusion that the attractiveness of the composite face is a human universal. Supporting cross-cultural evidence is however available. In a study by the author (summary results, not including those from China were reported in Shepherd, 1989) attractiveness judgements of composite versus individual caucasian faces were made by young people of four different races living in five different cultural settings. All were presented with twelve sets of female and eight sets of male faces. Each set consisted of six New Zealand caucasian faces and a seventh, photographic composite face constructed from them by Galton's method (Galton 1883, Appendix B).

## METHOD

### *The composite faces*

To produce the composites faces, 150 Caucasian members of a large first year psychology class at the University of Canterbury volunteered their faces to be photographed. Monochrome photographs were taken under standard distance and lighting conditions, full face, with spectacles and facial jewellery removed. They were visually sorted according to face shape and size, into groups of six. Faces not chosen

were those whose bearers had blinked, which had gross defects or which had a shape which was not sufficiently common to combine readily with another five. Photographic composites were made from each group by brief exposure of individual faces to produce a composite print. Non-hairy margins of the individual faces were lightly "hazed" during printing to match the blurring which characterised the margins of the composites. Each composite was positioned randomly in its group of six individuals to produce twelve sets of seven female and eight sets of seven male faces. The sets were mounted in groups of four, reduced photographically, screened to 100 mesh and printed on 29cm x 21cm sheets. The final printed size of each face was approximately 1.5cm x 2cm. Each face in each set was identified numerically. The effect of screening and size reduction was to obliterate skin blemishes which clearly distinguished some individuals from composites in the original photographs. Groups of five sheets containing the twelve female and eight male sets were stapled together with the female faces presented first.

### *Procedure*

New Zealand students were each presented with the booklet of faces and asked to, "choose in each set of seven faces the one you think is most attractive, the one you like best. Indicate this face by putting a circle around its number." They were asked to state their sex, age, ethnic origin and the number of years they had lived in New Zealand.

Nigerian, Indian and Chinese students each received the same booklet of faces, and an answer sheet listing the numbers of the faces in each set. They were asked to indicate their preferred faces by circling numbers on the answer sheets. Nigerian and Indian students were given instructions on the answer sheet in English, while instructions for Chinese students were printed in Chinese. All were asked to give their sex, age and ethnic origin.

Subjects were asked to choose in each set, the face they thought most attractive. All were tertiary students in their respective countries; New Zealand (University of Canterbury-New Zealand caucasians, and Chinese who had lived in New Zealand for between one and four years), India (indigenous students at the University of Lucknow), China (indigenous students at Lhazou Railway College), and Nigeria (indigenous male students at the University of Sokoto, women did not attend the university). Two scores were calculated for each student: the percentage of composite female faces chosen (from a

total of twelve) and the percentage of composite male faces chosen (from a total of eight).

## RESULTS

Analysis of variance of these data was carried out with ethnic group and gender of subject as between subject factors and sex of face as a within subject factor. (Nigerians, with no data available from female students, were omitted from the analysis.) The analysis yielded significant main effects for ethnic group [ $F(3,361) = 27.07$ ,  $p < .0001$ ], gender of subject [ $F(1, 361) = 7.22$ ,  $p < .01$ ] and sex of

**Table 1. Mean percentage choice of composite male and female faces tested against a chance expectancy of 14.28%.**

| Group tested   | Gender of face | Percentage choice | t      | p      |
|--|----------------|-------------------|--------|--------|
| NZ Caucasian men, N=59<br>Mean age 22 yrs 8 months   | Female faces   | 62.49             | 15.440 | <.0001 |
|  | Male faces     | 32.03             | 5.367  | <.0001 |
| NZ Caucasian women, N=50<br>Mean age 21 yrs 5 months | Female faces   | 52.25             | 11.823 | <.0001 |
|  | Male faces     | 22.25             | 3.650  | =.0006 |
| NZ Chinese men, N=23<br>Mean age 21 years 8 months   | Female faces   | 65.89             | 11.952 | <.0001 |
|  | Male faces     | 30.11             | 2.946  | =.0077 |
| NZ Chinese women, N=28<br>Mean age 20 yrs 8 months   | Female faces   | 66.65             | 12.431 | <.0001 |
|  | Male faces     | 37.02             | 4.916  | <.0001 |
| Indian men, N=50<br>Mean age 24 yrs 3 months         | Female faces   | 31.35             | 5.439  | <.0001 |
|  | Male faces     | 15.93             | 0.716  | =.4773 |
| Indian women, N=59<br>Mean age 24 yrs 4 months       | Female faces   | 33.58             | 6.687  | <.0001 |
|  | Male faces     | 19.70             | 2.413  | =.0190 |
| Nigerian men, N=91<br>Mean age 24 yrs 3 months       | Female faces   | 29.19             | 5.760  | <.0001 |
|  | Male faces     | 16.97             | 1.304  | =.1957 |
| Chinese men, N=50<br>Mean age 21 yrs                 | Female faces   | 54.31             | 10.916 | <.0001 |
|  | Male faces     | 24.76             | 3.923  | =.0003 |
| Chinese women, N=53<br>Mean age 19 yrs 1 month       | Female faces   | 48.06             | 10.338 | <.0001 |
|  | Male faces     | 21.15             | 2.685  | =.0098 |

face [ $F(1,361) = 442.81, p < .0001$ ]. Of the interactions, only ethnic group  $\times$  sex of face was significant ( $F(3,361) = 11.015, p < .0001$ ).

Table 1 presents the mean preferences for composite male and female faces by male and female students in each ethnic category. (Data from Nigerian men have been included in this table although they were not included in the analysis of variance.) Probability values are those against a null hypothesis of  $M = 14.28\%$ . All groups showed significant preferences for both male and female composites, with the exception of Indian and Nigerian men who showed only chance responses to composite male faces. All groups showed a significantly greater preference for female than for male composites. The preference for the composite caucasian face was greatest for students living in New Zealand followed closely by indigenous Chinese students, and was lowest for indigenous Indian and Nigerian students. The significant interaction resulted from a weaker preference for female over male composites by Indian students.

To gain a measure of agreement between the nine groups of students in their ordering of the faces, each face was given a score representing the numbers of individuals in each group who chose it as the most attractive in its set. Correlations ( $r$ ) were then calculated between all pairs of groups.

Correlations averaged  $+0.752$  ( $S.D. = .125$ ) for female faces and  $+0.589$  ( $S.D. = .138$ ) for male faces and all were significant beyond the 1% level. The level of agreement in ordering female faces ( $M = +0.752, S.D. = .125$ ) was significantly higher [ $t(35) = 8.589, p < .001$ ] than agreement in the ordering of males faces ( $M = +0.589, S.D. = .138$ ).

## DISCUSSION

These data suggest that something more than social learning was influencing the judgments, at least of female facial attractiveness. It is difficult to avoid the conclusion that these young adults belonging to very different ethnic groups, were behaving as members of the same species and not merely as products of their own different cultures. Some supporting evidence comes from the finding of Samuels and Ewy (1985) that both three and six month old human infants discriminated between photographs of faces which were similar in gross physical appearance but differed in attractiveness rated by adults.

But there is also evidence of cultural influences on the students'

judgments. Preference for the composite New Zealand caucasian faces was stronger among students exposed directly to New Zealand cultural norms than among those remote from that culture. Among the non-caucasian students, Chinese who had lived in New Zealand exhibited the highest levels of agreement with New Zealand students in their ordering of New Zealand caucasian faces.

Whereas Langlois and Roggman found similar attractiveness ratings for male and female composite faces, in these data there is consistently more frequent choice of female composites, and in the case of Indian and Nigerian men, the composite caucasian male face is chosen no more often than would be expected by chance.

If our perception of composite faces as attractive is the result of an evolutionary process of stabilizing selection towards the average, it becomes necessary to explain why this process has been less powerful (or perhaps, is more modifiable by social learning) in the case of male faces. It might be that facial attractiveness is more crucial for men's preferences for women, but not vice versa. Certainly Buss (1989) found physical attractiveness to be a stronger determinant of male than female partner choice in thirty seven different human cultures.

A more serious problem with Langlois and Roggman's explanation in terms of stabilising selection stems from their assumption that the composite face is an average and hence a prototypical face. While both the photographic composite and that produced by averaging matrices of numeric grey values yield a credible face in which areas of light and dark have been averaged, it is not clear that this is an average face in any prototypical sense. The very fact that composite faces are perceived as more attractive than individual faces indicates that they are not typical with respect to attractiveness. Facial averageness in a prototypical sense might better be measured by the median than the arithmetic mean - by selecting the individual face which differs least from other individual faces. While the median face might thus be a face which had no distinctive features, it is likely that the composite face is characterised by distinctive features. Superimposing individual features, whether photographically or digitally, will tend to produce a composite feature that is larger than the median feature. This is because the larger individual features will still be represented in the composite, albeit more faintly, and may add to its perceived size. Just what are the perceived boundaries of a composite feature would need to be established before it could be accepted as an average feature.

Empirical studies to date have demonstrated only that the

composite face is an attractive face, whether it is computer generated or produced photographically. It remains to be shown that the composite face is an average face in any generally accepted prototypical sense or that it is perceived as an average face in a popular sense or that it is regarded as typical of any particular class of faces. In the meantime we may conclude only that the attractiveness of the composite face is a phenomenon of human perception that remains robust across wide ethnic and cultural boundaries. We may not conclude that it is a prototypical face the perceived attractiveness of which results from an evolutionary process of stabilizing selection.

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## THE COMPLETE RED APE

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**Orang-Utans in Borneo** by Gisela Kaplan and Lesley J. Rogers.  
University of New England Press, 1994.

*Orang-Utans in Borneo* offers an unique and altogether engaging treatment of its topic. Indeed, authors Gisela Kaplan and Lesley Rogers seem to have created a new genre. The great breadth of scholarship of each author is complementary to that of the other. The result is an exceptionally rich context of geography, ecology, politics, economics, history, and culture within which the central themes unfold. Broadly taken, one theme is the precarious status of orang-utans worldwide, including the very real and immediate pressures forcing their situation. The authors emphasize the cognitive complexity and sociability of orang-utans which has often been underestimated in comparison with other great ape species. These capacities, as well as other behavioral and structural similarities between orang-utans and humans, raise the questions about primate phylogeny which constitute a second theme.

On yet another level, it is the story of two humans who first had a personal encounter with an orang-utan named Abbie and subsequently were deeply affected by many others. In the authors' words:

We cannot even begin to express our views on how we feel about this species other than to say that the orang-utan is a fascinating being. If we are able to convey anything of their subtlety, complexity and sensitivity that will lead one to feel a deep respect for their right to be, then the book will have done its most important work. (p.5)

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For this reader, the book was a complete success in developing an appreciation of the orang-utan as "a fascinating being".

The text begins by setting forth the human cultural context of ideas about orang-utans. In a world where human choices and behaviors are the principal factors that threaten the continued existence of species, how the orang-utan is regarded by humans is an essential concern. The authors present a well-documented overview of Western attitudes towards orang-utans and other great apes that effectively illustrates how human belief systems have historically conditioned human behaviors to the detriment of other species. Because the book revolves around the orang-utans of Borneo, specifically those at the Sepilok and Semengoh Rehabilitation Centres of Sabah and Sarawak in East Malaysia, a wonderfully detailed account is given of the geography, demographics, politics, and economics of these regions. This account delineates the practical context within which the survival or extinction of the Bornean orang-utan will be determined. Finally, the context of attitudes of the indigenous populations of Sarawak and Sabah is reflected in local stories of the orang-utan.

The second chapter explores the rainforest habitat of the Bornean orang-utans. The reader is acquainted with the geography of the shrinking forests and orang-utan populations through an excellent series of maps. Similarly, consideration of local plant species is enhanced by marvelous color photographs. The general consideration of the flora and fauna of the Bornean rainforests is supplemented by a very useful discussion of the special problems that are presented to the researcher wishing to study rainforest species. Lastly, rehabilitation centres, national parks, and reserves as habitats for orang-utans are described with special attention to the Sepilok Rehabilitation Centre where much of the behavioral research of Kaplan and Rogers was conducted.

Chapters 3 and 4 are unified by the issue of the similarities among orang-utans, humans, and other great apes. Anatomical structures, genetics, and a variety of behaviors are considered. Appendix 2 (p.159) lists 27 morphologies shared between humans and orang-utans but only 9 among humans, chimpanzees, and gorillas. The authors argue that the DNA evidence is still open to debate. The question of human/orang-utan similarity is pursued with intriguing, in-depth considerations of posture and locomotion, feeding habits, and sexual and maternal behaviors.

The reader is introduced to the authors' study of population in Chapter 5 together with a thoughtful consideration of the effects of

environment and prior experience on the generalizability of the results of behavioral studies. Wild populations of orang-utans are difficult to study because of their solitary and arboreal habitat. Thus, most behavioral studies of this species have been done in zoos or other settings with variable prior human contact. The authors characterize their study group as "semi-wild", i.e., born in the wild, currently living free, but having had some transient contact with humans.

The authors' laterality studies are presented within the larger issue of similarities of brain structure and cognitive behaviors between humans and the great apes. In their study group of orang-utans, many behaviors were examined for evidence of lateral bias. Face touching with the left hand was the most strongly lateralized behavior identified, a directional bias shared with humans and perhaps other great apes. The authors interpret this as evidence of functional specialization of the cerebral hemispheres. Evidence of tool using, problem solving, communication, and sign language is reviewed to permit comparison of the cognitive abilities of orang-utans with those of other great apes. The authors conclude that the orang-utan has proved equally talented to other great apes, perhaps even more gifted.

The epilogue returns to the theme of endangerment and preservation. It is a concise but powerful statement about the current state of affairs worldwide that affect the survivability of the orang-utan with suggested solutions and a plea that time is running out for the wild populations of orang-utans.

This is a wonderful book. It was intended for a mixed audience of primatologists, zoo personnel, conservationists, and general readers. It does not miss the mark. This book is exceedingly readable and, at the same time, thoroughly informative about orang-utan structure, behavior, and habitat, as well as a variety of issues affecting orang-utans. It is furbished with glorious color photographs to illustrate relevant points, while also characterized by careful scholarship and appropriate use of references throughout.

One aspect of the book which this reviewer particularly enjoyed is the frank personal involvement and admitted caring of the authors. It is rare that scientists of this calibre admit to the passions that drive them in their studies. This work is all the more effective for their honesty. I can only hope the book finds its way to the libraries, laboratories, classrooms, offices, and homes around the world where it may have its intended effect.

## **Call for Papers**

### **7TH MEETING OF THE INTERNATIONAL SOCIETY FOR COMPARATIVE PSYCHOLOGY**

**Concordia University, 1455 De Maisonnueve Blvd. West  
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Submissions are now being accepted for papers, posters and symposium for the 7th Biennial Meeting of the ISCP being held at Concordia University from August 14-16, 1996 immediately prior to the International Congress of Psychology.

Details concerning submissions are available from Dr Nancy Innis. Submissions must be received by February 15, 1996.

Accommodation has been arranged at the Chateau Versailles, an excellent hotel located centrally in downtown Montreal and walking distance from the Metro (subway) station. The rate for participants in the 7th Meeting of the ISCP is below that for comparable hotels on the International Congress list, and these same low rates may be maintained throughout the entire ICP meeting. Please register early for your accommodation since there are only a limited number of rooms held for the ISCP.

The deadline for registration for the ISCP Meeting is April 15, 1996. Registration forms are available from the ISCP Conference Coordinator.

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